Powerless:
Northeast Blackout of 2003

Leadership ViTS Meeting
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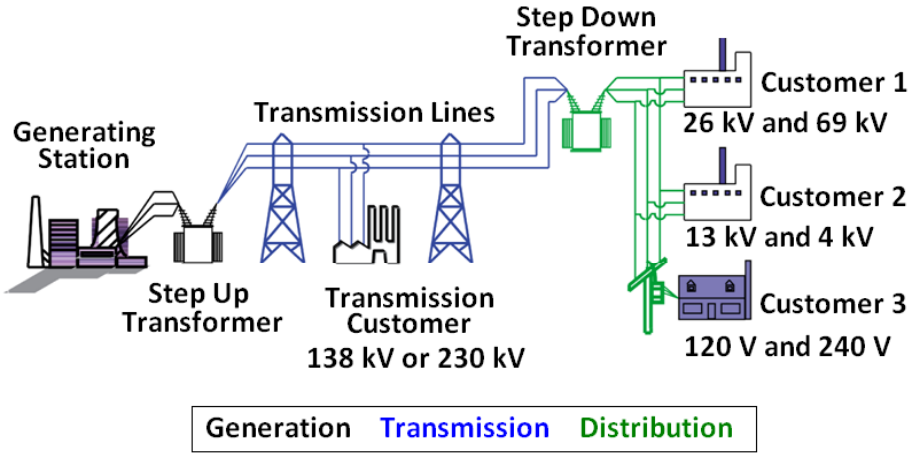
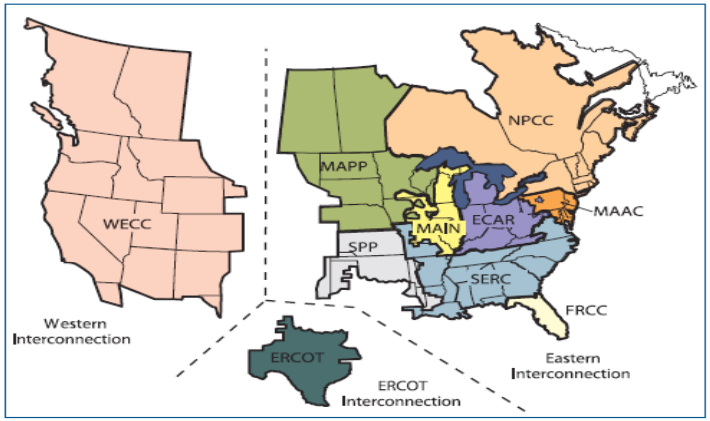
“The Grid”

- The North American power grid is a large interconnected system considered by many to be one of the greatest engineering achievements of the past 100 years.
- Over 200,000 miles of transmission lines distribute 950,000 megawatts of power at hundreds of thousands of volts.
- 3,500 utility organizations serve over 283 million people (in 2003) across an infrastructure valued at $1 trillion.

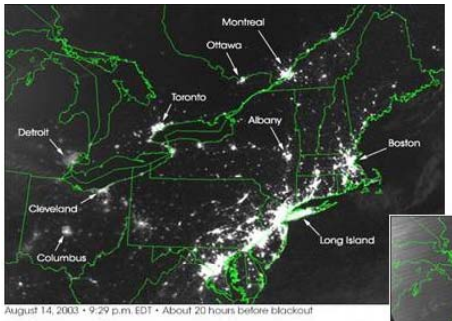




- The grid actually consists of *three* distinct power grids or “interconnections” that are electrically independent of each other.
- Overload of a transmission line or underload/overload of a generator requires utilities to disconnect the line or generator from the grid to prevent costly and hard-to-repair damage.

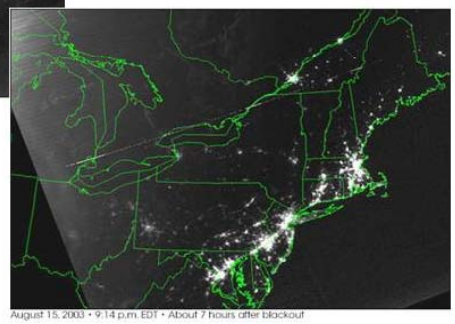
The Failure

- On the evening of August 14th 2003, the United States and Canada experienced the largest power blackout in North American history.
- The blackout, lasting up to several days in some locations, affected 40 million US residents and 10 million Canadians and cost about $6 billion in damages, including lost business, spoiled food, looting, etc.
- Systems to detect unauthorized border crossings and port landings failed during the blackout.



Before blackout

After blackout



Critical Events

- Northern Ohio FirstEnergy's Eastlake 5 power generation unit exceeded system limits when an operator attempted to increase output and automatic shutdown occurred.
- FirstEnergy's grid monitoring computer system alarm failed thus allowing the 1,500 megawatt load imbalance to go un-annunciated.
- The imbalance caused power surges which strained and overheated transmission lines, in turn, causing them to sag, contact overgrown trees, and then trigger a shut down.
- Within 7 minutes, a cascade of multiple line shutdowns had affected 9,300 square miles.

Proximate Cause

- The shutdown of the Eastlake 5 generator in northern Ohio caused a load imbalance which strained transmission lines and triggered a cascade of line shutdowns throughout the northeastern US and Canada as heavy power surges overheated lines causing them to sag, hit overgrown trees, and automatically shut down.

Root Causes/Underlying Issues

- **Lack of training and operator errors**
  - Operational planning studies and simulations conducted by FirstEnergy in 2002 and 2003 were insufficient in fully evaluating the Cleveland-Akron grid vulnerabilities.
  - Midwestern Independent System Operator turned off the auto trigger and alarm functions to fix a system error that day but forgot to turn them back on until after the blackout.
- **Lack of communication between power operations and IT staff**
  - IT personnel knew of control system crashes but did not notify power plant operators, instead performing “warm-reboots” of the computers to try and solve the problem.
- **Inadequate system planning and understanding**
  - Both plant operators and IT staff had insufficient macro-level understanding of their system and had no emergency response plans to deal with such failures. They were unprepared to react properly when problems arose.
- **Neglected ‘vegetation management’**
  - As transmission line loads increase, the generated heat causes lines to elongate and sag.
  - Power companies failed to prune trees sufficiently to prevent transmission lines from contacting the trees when the lines sagged.

NASA Applicability

- Overall design requirements must incorporate the needs of mission support personnel and provide an accurate, real-time, system-wide view of operational performance.
- Anticipating and developing effective contingency plans for all conceivable off-nominal scenarios is critical to an ability to recover from failures with the least amount of impact.
- Effective team communication is essential especially when lives and the success of critical missions are at stake.
- Ensuring that mission support operators have a macro-system understanding and have rehearsed their response to anticipated emergency situations will enable an appropriate response that can likely mitigate cascading and system-wide failures.